High Energy Laboratory Astrophysics using an X-Ray Microcalorimeter with an Electron Beam Ion Trap

Completed Technology Project (2016 - 2019)

Project Introduction

Since the summer of 2000 we have successfully deployed a high-resolution x-ray microcalorimeter spectrometer, based on the spaceflight XRS instrument, at the Electron Beam Ion Trap (EBIT) facility at the Lawrence Livermore National Laboratory. Over the last 15 years, this highly successful partnership has made fundamental measurements in laboratory astrophysics including the measurements of the absolute cross sections of all the Fe L shell transitions from Fe XVII to Fe XXIV, line ratios in Fe and Ni L shell transitions, measurements of Fe K shell emission over a wide range of electron energies, and direct measurements of charge exchange emission from highly ionized Fe, O, N, and most recently L shell S, using a variety of donor gases. This work has resulted in the publication of over 40 peer-reviewed articles with many more either submitted or in preparation. The newest addition to the facility, the ECS microcalorimeter spectrometer, developed under this program, has performed flawlessly as a facility-class instrument since 2007. We propose here to continue our highly successful partnership and deploy new technology to resolve lines in the important 1/4 keV band that encompasses the M-shell iron emission and the L shell emission, including charge exchange, of many of the lower-Z elements, such as Si, S, Mg, Ne, Ca, and Ar. We thus propose completing a new spectrometer that will bring substantially improved performance to the laboratory astrophysics program at EBIT and will enable fundamentally new measurements. Thus, in addition to maintaining the current spectrometers, which will begin this work, a significant component of this proposal is the completion of a new spectrometer leveraged off of the substantial progress in high-resolution x-ray detectors developed for the IXO and now Athena large- scale observatories. The spectrometer will be composed of a detector system with unparalleled spectral resolution: 2 eV resolution across the 0.05-10 keV band. This will allow us to disentangle line blends for nearly every high energy emission line over the entire astrophysical spectrum using the non-dispersive, highly efficient microcalorimeter instrument alone and in concert with the high resolution but narrow band dispersive spectrometers at the LLNL EBIT facility. This work is highly relevant to NASA objectives as it allows for the unambiguous connection between spectroscopic observations with Chandra, XMM, Astro-H, and future spectrometers aboard missions like Athena, and the physics occurring in the cosmological source. Our program aids these measurements by benchmarking the spectroscopic synthesis models used to interpret all x-ray observations. Without laboratory measurements to support these models, it is not a priori certain that the models are correct, and the observational data correctly interpreted. This is especially true for charge exchange measurements, where there are substantially differences between theory and measurement in K shell emission, and no useful theory at all in L shell emission.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

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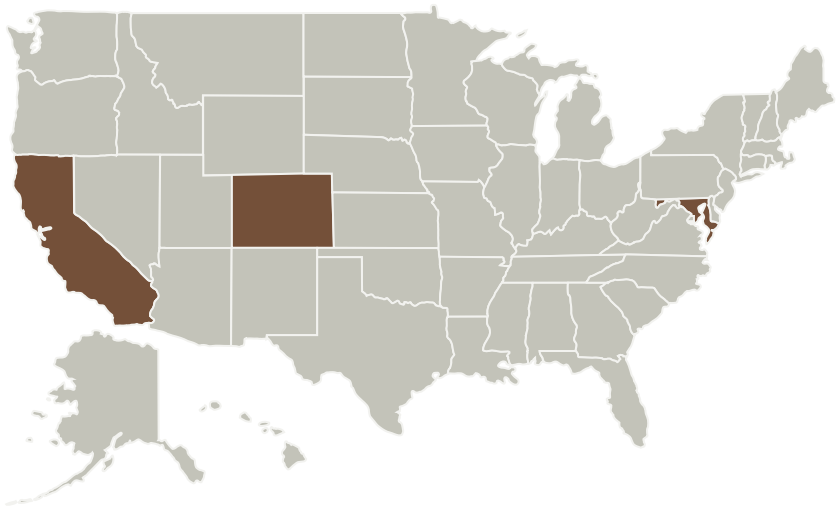
Primary U.S. Work Locations and Key Partners



Primary U.S. Work Locations	
California	Colorado
Maryland	

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Frederick S Porter

Co-Investigators:

Carl D Reintsema
Stephen J Smith
Caroline A Kilbourne
Simon R Bandler
Megan E Eckart
Richard L Kelley
Gabriele L Betancourt-martinez
Peter Beiersdorfer
Keith M Jahoda
Joseph S Adams
Maurice A Leutenegger
Joel Ullom
Gregory V Brown

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System